NASA CONNECTICUT SPACE GRANT CONSORTIUM

D-BEST Lab
Digital / Biomedical Embedded Systems & Technology Lab

ECG-Based Cardiac Assessment for Microgravity and High-Altitude Atmospheres

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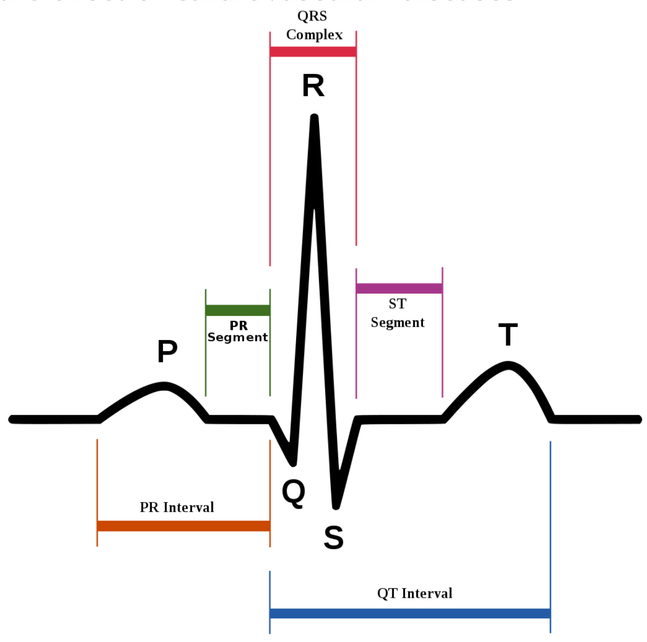
Abstract

This research project focuses on the electrocardiogram (ECG) signal characteristics and introduces novel methods to identify certain types of arrhythmia and/or the onset of heart attack with high accuracy. This is especially important as fatal heart episodes have been reported in connection with takeoffs and landings as well as high-altitude atmospheres. Signal processing techniques will be employed to identify ECG characteristic feature points and then machine learning will be applied to classify the signal into healthy or classes of irregular ECG beats. The proposed techniques are intended to conveniently assist monitoring the heart functionality in conditions such as aerospace environments.

ECG Signal

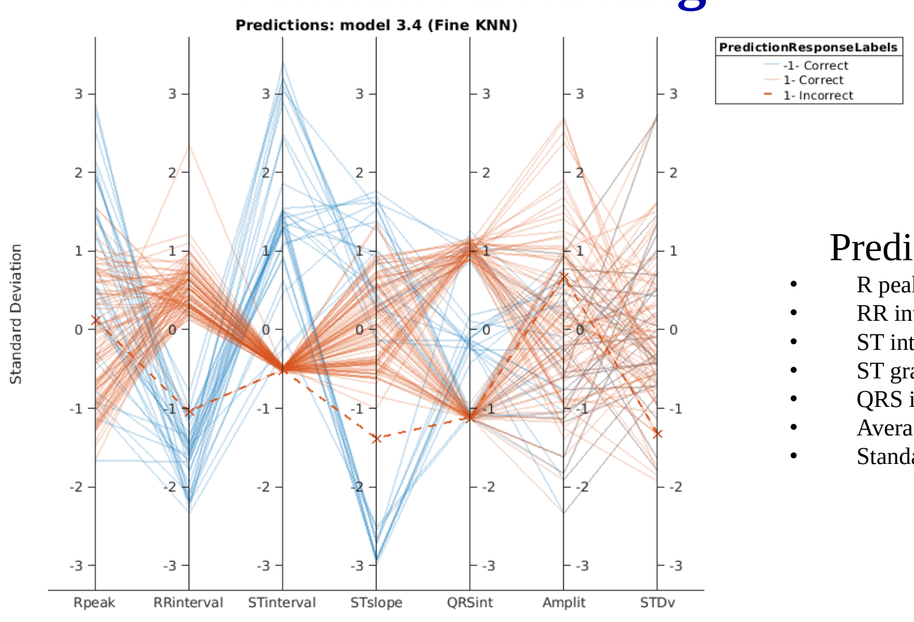
- Electrocardiogram (ECG/EKG) shows the activity of the heart by graphing its voltage versus time
- ECG signals help physicians understand issues with the heart such as chest pains or shortness of breath
- ECG signals have key features called the ‘P Q R S T’ waves which help physicians identify the issues and the onset of cardiovascular diseases [1]



Proposed Methodology

- The objective is to classify ECG readings from subjects under-going microgravity and high-altitude atmosphere
- First classify regular ECG signals from known health database [2] to understand the basics
  - Denoise ECG signals to get a clearer signal to help find key features
  - Apply Chebyshev’s filter to fix baseline wandering
  - Classify each key feature from the clean signal
- Implement classification algorithm on artificially noisy ECG signal to replicate reading during microgravity and high-altitude environments

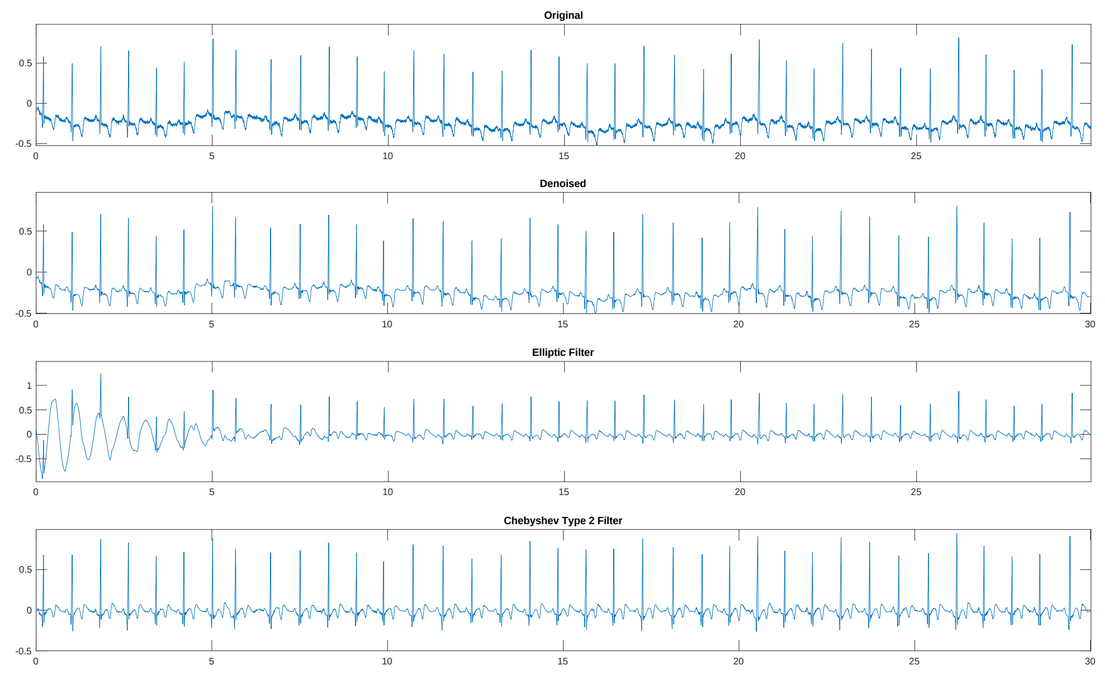
Machine Learning



Predictors:

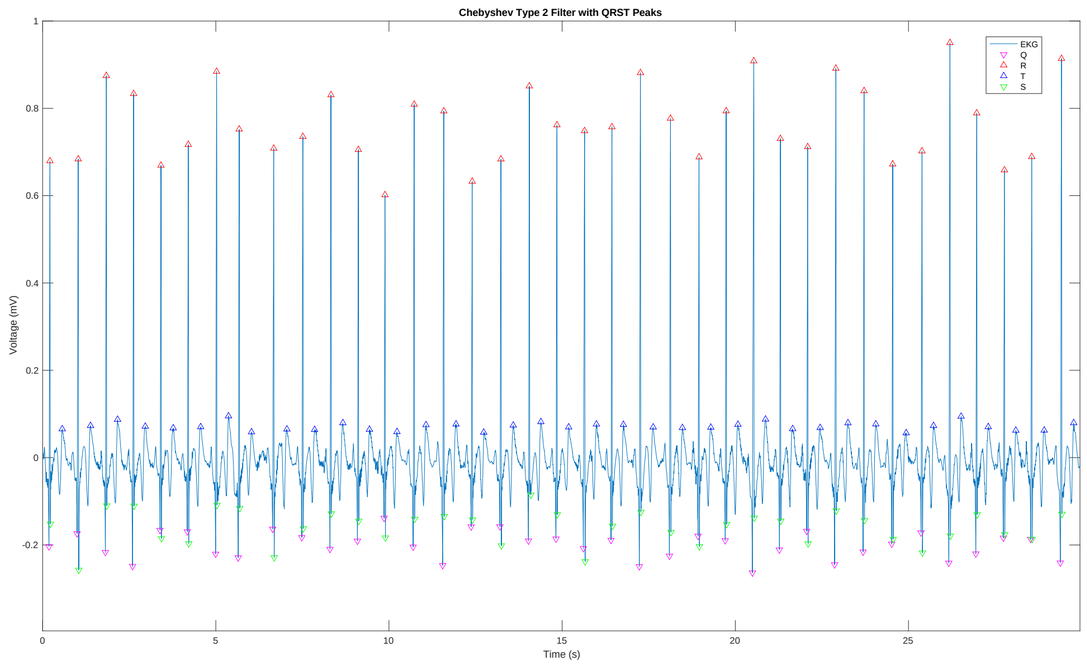
- R peak amplitude
- RR interval
- ST interval
- ST gradient
- QRS interval
- Average amplitude
- Standard deviation

ECG Denoising



- Wavelet analysis removes electromagnetic interference - imperative for high altitude and microgravity ECG analysis due to presence of circuitry and solar radiation in such environments
- Elliptic filtering stabilizes signal to remove baseline wandering
- Chebychev filtering further stabilizes the signal

Feature Classification



- QRS inflection points and T wave classification achieved via algorithmic localized peak detection as a function of signal maxima, mean amplitude, relative peak distance, and peak prominence

Prediction Accuracy

- Using a Fine Nearest Neighbor Classifier for supervised machine learning resulted in an accuracy rate of 99.7% in determining if a beat was classified as normal or abnormal
- Aberrated atrial premature beat ground truths were primarily used to train classifiers

Acknowledgements

- The authors would like to acknowledge NASA Connecticut Space Grant Consortium for funding this research project.

References

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- [2] PhysioNet: https://archive.physionet.org/physiobank/database/